

The THU-NAOC Transient Survey: the Performance and the First-year Result

Tianmeng Zhang,¹ Xiaofeng Wang,² Junchen Chen,² Jujia Zhang,^{3,4,5} Li Zhou,² Wenxiong Li,² Qing Liu,² Jun Mo,² Kaicheng Zhang,² Xinyu Yao,^{2,6} Xulin Zhao,² Xu Zhou,¹ Jundan Nie,¹ Fang Huang,^{2,7} Zhaoji Jiang,¹ Jun Ma,¹ Lingzhi Wang,¹ Chao Wu,⁸ Zhimin Zhou,¹ Hu Zou,¹ Lifan Wang⁶

¹ Key Laboratory of Optical Astronomy, National Astronomical Observatories, Chinese Academy of Sciences, Beijing 100012, China; zhangtm@nao.cas.cn

² Physics Department and Tsinghua Center for Astrophysics (THCA), Tsinghua University, Beijing 100084, China; wang_xf@mail.tsinghua.edu.cn

³ Yunnan Observatories (YNAO), Chinese Academy of Sciences, Kunming 650011, China

⁴ Key Laboratory for the Structure and Evolution of Celestial Objects, Chinese Academy of Sciences, Kunming 650011, China

⁵ University of Chinese Academy of Sciences, Beijing 100049, China

⁶ Purple Mountain Observatory, Chinese Academy of Sciences, Nanjing, 210008, People's Republic of China

⁷ Astronomy Department, Beijing Normal University, Beijing 100875, China

⁸ National Astronomical Observatories, Chinese Academy of Sciences

Abstract The Tsinghua University-National Astronomical Observatories of China (NAOC) Transient Survey (TNTS) is an automatic survey for a systematic exploration of optical transients (OTs), conducted with a 60/90 cm Schmidt telescope at Xinglong station of NAOC. This survey repeatedly covers ~ 1000 square degrees of the north sky with a cadence of 3–4 days. With an exposure of 60 s, the survey reaches a limited unfiltered magnitude of about 19.5 mag. This enables us to discover supernovae at their relatively young stages. In this paper, we describe the overall performance of our survey during the first year and present some preliminary results.

Key words: Supernovae; Quasars and Active Galactic Nuclei; Stars

1 INTRODUCTION

Time-Domain Astronomy (TDA) has been recognized as one of the most active and promising research field in astrophysics and is growing rapidly over the past few years. It touches on the understanding of different types of known and unknown transients (or outburst phenomenon) in the universe, such as variables, supernovae, gamma-ray burst, quasars, active galactic nuclei (AGN), and tidal disruption event (TDE) etc.. Wide-field surveys for the transients in the universe open new frontiers in astrophysics.

Owing to diverse scientific objectives, many consortiums have thus put efforts in such surveys by using small- to mediate-size wide-field telescopes, including the Palomar Transient Factory (PTF; Law et al. (2009)), the La-Silla Quest South Hemisphere Variability Survey (LSQ; Baltay et al. (2013)), the Panoramic Survey Telescope and Rapid Response System (PanSTARRS; Kaiser et al. (2002)), the SkyMapper Southern Sky Survey (Keller et al., 2007), and the Catalina Real-Time Transient Survey

(CRTS; Drake et al. (2009)). The next generation large telescopes such as the Large Synoptical Survey Telescope (LSST; Tyson et al. (2003)) will also focus on the time-domain astronomy in the near future.

The Tsinghua University-National Astronomical Observatories of China (NAOC) Transient Survey (TNTS) is an optical survey conducted with a relatively short cadence (e.g., 3-4 days) compared to the existing wide-field transient surveys, aiming primarily at detections of relatively young supernovae in local universe. The early detection enables us to better understand the progenitor system and the explosion physics of SNe. The spectroscopic identifications of our discovery are obtained primarily with Yunan Observatories (YNAO) 2.4-m telescope at Lijiang Station and NAOC 2.16-m telescope at Xinglong Station. The follow-up photometric observations are obtained with the Tsinghua University-NAOC 0.8-m telescope (TNT¹) at the Xinglong Station.

In this paper, we present the performance and the first year results of our survey. The observations and data reduction are described in Section 2, and Section 3 presents the results. Our summaries are given in Section 4.

2 DESCRIPTION OF PROJECT

2.1 Instruments

The TNTS is conducted with a Schmidt telescope (with a 90-cm spherical primary mirror and a 60-cm Schmidt corrector plate), located at the Xinglong station of NAOC. One 4096×4096 CCD camera with a plate scale of 1.3 arcsecond per pixel is mounted at the Schmidt focus of the telescope. The field of view (FoV) of the CCD is $90' \times 90'$. A detailed description of this telescope was given by Zhou et al. (2003). Under a moonless and clear night at Xinglong station, this telescope and the CCD system can reach a detection limit of about 19.5 mag (3σ) with the clear filter for an exposure of 60 s. This magnitude limit can detect a normal SN Ia at $z \sim 0.04$ at about two weeks before its B -band maximum light.

2.2 Survey Strategy

The TNTS is designed to operate for four years starting from October 2012. This survey covers a sky area of ~ 1000 square degrees with Galactic latitude $|b| > 10^\circ$ and longitude in the range $0^\circ < \delta < 60^\circ$. The nearby galaxy clusters such as the Coma cluster and most part of the Virgo cluster are also included in our survey field, with an intent of catching events of some extremely young supernovae. It usually takes about 2 minutes to take an image for a specific sky field, including 60-s exposure, 22-s readout time, and 30 s for movement and stabilization of the telescope. In order to efficiently rule out the cosmic rays and moving objects, we take two exposures for each sky field with a temporal interval of about 1.0-1.5 hour. The transients with very short timescales of light variations will also benefit from such an observation mode. This means that the whole survey area can be repeatedly visited every 3 to 4 days. Figure 1 shows the sky areas covered by the TNTS, and the red dots are the supernovae candidates discovered during the first-year survey.

2.3 Data-Reduction Pipeline

An image processing pipeline has been developed for the TNTS based on some open source softwares. The software *SExtractor* is used to find objects and produce the catalogs for each image (Bertin & Arnouts, 1996). With these catalogs, the astrometric parameters are obtained by *SCAMP* (Bertin et al., 2006). The *SWarp* software is used to resample and align the new images to the reference images (Bertin et al., 2002). After performing the above steps, we apply the image-subtraction technique to detect possible candidates on the residual images. The residual image is obtained by subtracting the reference image from the new image with the High Order Transform of Point Spread Function (PSF)

¹ This telescope is co-operated by Tsinghua University and the National Astronomical Observatories of China (NAOC)

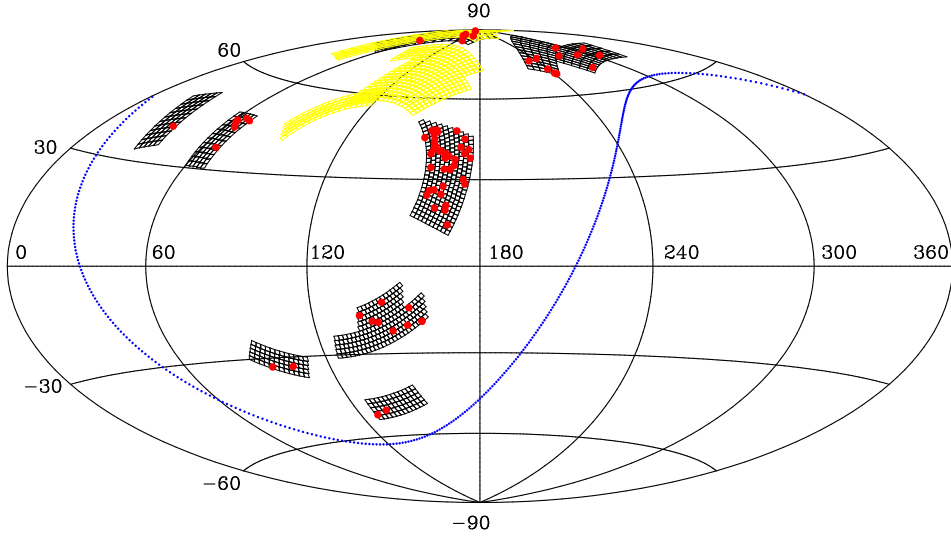


Fig. 1 The sky area covered by TNTS in Galactic coordinate system. Each small square represents the FoV that the TNTS can cover with one exposure. The yellow regions are the fields that will be covered in the next stage. The red dots represent the SNe candidates discovered by TNTS. The blue line is the celestial equator.

and Template Subtraction (*HOTPANTS*²). This code is effective in detecting the SNe exploding near the central regions of their host galaxies. All these codes and softwares are assembled by *bash* scripts of linux. Hundreds of sources can be detected on each residual image due to the large field of view of the TNTS, but most can be attributed to artifacts of image subtraction. A series of criteria, such as ellipticity, FWHM, and contamination from bright stars, are applied to rule out the false detections. The remained candidates will be examined carefully by eyes. The most possible candidates will be posted on ATels or CBAT to alert instantly the community to initiate the follow-up observations.

2.4 Follow-Up Observations

For SNe or other interesting transients discovered by the TNTS at a magnitude brighter than 18.0 mag and are on the rise, we will generally trigger the follow-up observations in photometric and spectroscopic modes. In particular, extensive follow-up observations will be obtained for those SNe discovered at relatively young phases. The photometric observations are performed with the 0.8-m TNT telescope located at NAOC Xinglong Observatory (Wang et al., 2008; Huang et al., 2012) in the standard Johnson *UBV* (Johnson et al., 1966) and Kron-Cousins *RI* (Cousins, 1981) filters, with a 1340×1300 pixel back-illuminated CCD and a FoV of $11.5' \times 11.2'$ (pixel size $\sim 0.52'' \text{ pixel}^{-1}$). Spectroscopic observations are taken by the Cassegrain spectrograph and BAO Faint Object Spectrograph & Camera (BFOSC) mounted on the 2.16-m telescope and Yunnan Astronomical Observatory (YNAO) Faint Object Spectrograph & Camera (YFOSC) mounted on the 2.4-m telescope at Lijiang Station of YNAO (Zhang J. et al., 2012a). Our goal is to obtain a uniform SN sample with well-sampled *UBVRI* light curves and spectroscopic data covering premaximum-, maximum-, and post-maximum phases.

² See <http://www.astro.washington.edu/users/becker/hotpants.html> for the details

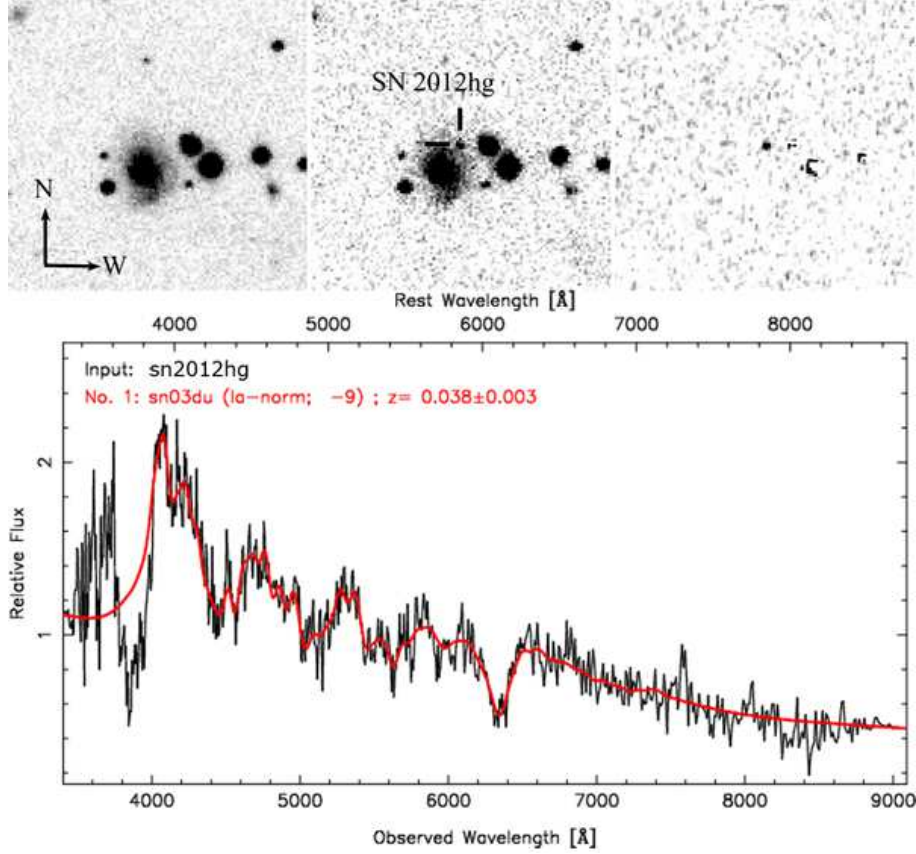


Fig. 2 The discovery images and spectroscopic identifications of SN 2012hg. Left-up: the template without the SN; Middle-up: the discovery image with the SN; Right-up: the subtracted image with only the SN. Lower panel: the spectrum of SN 2012hg taken by the 2.4-m telescope. The red line is the best-fit spectrum from SN 2003du at -9 days in the library of SNID (Blondin & Tonry, 2007).

3 THE FIRST-YEAR RESULTS

A total of about 30,000 images were obtained during the first-year survey, which yields over 50 SN candidates and lots of other transients such as variable stars, novae, and Quasars/AGNs. 44 SNe finally got spectroscopic identifications from the observations by us and other groups, and the discovery and classifications were published on the CBETs and ATels (See also Table 1).

Figure 2 shows the first supernova 2012hg detected by the TNTS. It was discovered on Nov. 25.8 UT at a magnitude of about 18.0 mag. The light curve shows that this SN was actually discovered at about 16 days before its maximum light (see also Figure 5). In Figure 3, we show the spectrum of type IIIn SN 2013dw, which is the most distant SN discovered by the TNTS, with a redshift of 0.136 (Zhou L. et al., 2013i). The relevant parameters of the SNe discovered during our first-year survey are listed in Table 1.

Figure 4 presents some statistic properties of the first-year SN sample from the TNTS, including the discovery magnitudes, the redshift of the SNe, discovery phase and the spectral types. Figure 4a shows the histogram distribution of the discovery magnitudes of our SN sample. The mean discovery magnitude is ~ 18.2 mag, which is brighter than the detection limit of TNTS by about 1.0 mag. Figure

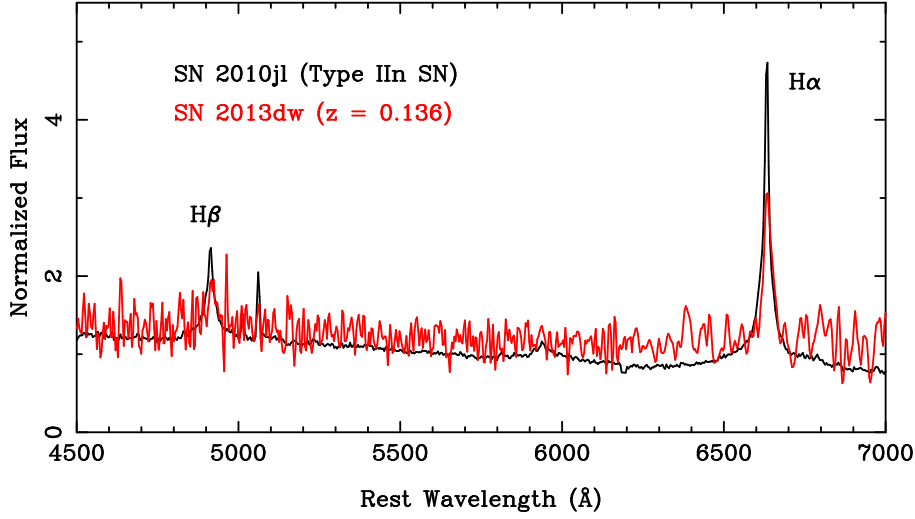


Fig. 3 The spectrum of bright type II SN 2013dw taken by 2.16-m telescope. The redshift of the host galaxy is corrected. The red line is the spectrum of SN 2010jl at about one month after maximum as comparison (Zhang T. et al., 2012).

4b shows the redshift distribution the first-year TNTS SN sample, with a mean value of 0.05. Of this sample, 31 are type Ia SNe, 10 are type II, 3 are type Ibc and 6 are probably SNe without spectral classification (see Figure 4d). The observed fractions of SNe of different spectral types are consistent with those obtained from other magnitude-limited sample (e.g., Li et al. (2011)), which is 17% for SNe II, 79% for SNe Ia and 4% for SNe Ibc, respectively. The higher fraction of SNe Ia is expected in a magnitude-limited survey, as they are on average much brighter than SNe II and SNe Ibc. For SNe Ia, we notice that about 80% were detected before or around their maximum light, as shown in Figure 4c. The discovery ages of these SNe Ia at discovery were estimated from the unfiltered light curves. Figure 5 illustrates the unfiltered (*R*-band) light curves of five young SNe Ia discovered from the TNTS, which were discovered at about two weeks before the maximum light. These facts prove the capability of TNTS to detect SNe at a relatively young phase. Extensive follow-up observations have also been obtained for these SNe discovered at young phases. The light curves of SN 2012ij indicates that it is a subluminal SNe Ia discovered at about 2 weeks before the maximum light, which shows spectroscopic features similar to the subluminal object SN 1991bg (Chen et al., 2014). SN 2013gs is another young SNe Ia with extensive optical and *Swift* UV observations. The spectra of SN 2013gs are characterized by high-velocity Si II absorption and it seems to be bright in UV bands (Zhang T. et al., 2014).

Besides supernovae, a number of other optical transients were also detected during our survey. These include 5 cataclysmic variables (CVs) or novae candidates, 15 active galactic nucleus (AGNs), and about 150 variables (Yao et al., 2014). Among the 150 variables, 37 are new detections. All of the optical transients discovered by the TNTS can be automatically monitored in an unfiltered mode during the survey. The statistic analysis of variance method, introduced by Stetson (1996), is used to search for the periodicity of these possible variables. As an example, we show in Figure 6 the phase light curves of two periodic variables found by this method (see Yao et al. (2014) in details). The preliminary results about the variables prove that, the TNTS has capability to detect variables with different period from hours to months. The survey data can be also used to study the light variations of AGN/quasars. Figure 7 shows the light variations of a flat-spectrum radio quasar (FSRQ) J1310+3233 with a redshift of 1.6 (Healey et al., 2008). The unfiltered light curve indicates that, the luminosity of this quasar has a long-

Table 1 The information of confirmed Supernovae discovered by the TINTS.

Designation	Type	R.A.	Dec	Redshift	Discovery Mag	Discovery Date (UT)	Reference
SN 2012hg	Ia	07:07:25.60	+56:18:19.2	0.038	18.0	Nov. 25.8 2012	CBET 3330 (Zhao X. et al., 2012)
SN 2012hm	Ia	02:33:23.32	+39:40:16.9	0.036	17.8	Dec. 07.6 2012	CBET 3336 (Zhang J. et al., 2012b)
SN 2012hq	Ia	02:07:30.50	+44:06:19.3	0.090	18.6	Dec. 07.7 2012	CBET 3344 (Wang et al., 2012)
SN 2012hw	IIP	09:41:38.02	+48:40:25.5	0.038	17.9	Dec. 22.9 2012	CBET 3353 (Howerton et al., 2012)
SN 2012ic	Ia	03:13:53.71	+33:58:03.7	0.040	17.4	Dec. 22.7 2012	CBET 3360 (Zhou L. et al., 2012)
SN 2012ie	Ia	02:24:22.35	+40:51:03.2	0.048	18.0	Dec. 23.5 2012	CBET 3362 (Tomasella et al., 2012a)
SN 2012ih	Ia	06:56:42.91	+48:54:10.3	0.019	16.4	Dec. 10.8 2012	CBET 3366 (Tomasella et al., 2012b)
SN 2012ii	Ia	07:16:55.48	+51:45:47.6	0.060	19.0	Dec. 23.8 2012	CBET 3369 (Zhou L. et al., 2013a)
SN 2012ij	Ia	11:40:15.84	+17:27:22.2	0.010	18.0	Dec. 31.8 2012	CBET 3370 (Marion et al., 2013)
SN 2012ik	Ia	07:35:26.91	+51:52:50.4	0.064	19.4	Dec. 23.8 2012	CBET 3383 (Luppi et al., 2013)
SN 2013N	Ia	11:50:04.13	+21:16:46.0	0.026	15.9	Jan. 26.8 2013	CBET 3394 (Zhou L. et al., 2013b)
SN 2013O	Ia	08:52:05.98	+52:36:06.2	0.053	18.3	Jan. 21.7 2013	CBET 3395 (Zhang T. et al., 2013a)
SN 2013S	Ia	03:35:30.29	+38:16:59.3	0.019	16.1	Jan. 25.6 2013	CBET 3406 (Zhou L. et al., 2013c)
SN 2013Z	IIP	13:27:54.89	+30:22:29.4	0.050	19.0	Jan. 24.9 2013	CBET 3415 (Inserra et al., 2013)
SN 2013ac	IIP	09:45:08.79	+58:40:07.3	0.035	18.2	Feb. 15.7 2013	CBET 3424 (Zhang T. et al., 2013b)
SN 2013af	IIP	09:13:55.17	+55:46:56.7	0.036	18.9	Mar. 01.5 2013	CBET 3427 (Zhou L. et al., 2013d)
SN 2013ah	Ia	09:44:33.80	+55:45:44.4	0.025	18.6	Feb. 22.6 2013	CBET 3430 (Elenin & Molotov, 2013)
SN 2013ap	Ia	12:58:24.92	+12:35:53.3	0.086	19.5	Feb. 18.9 2013	CBET 3443 (Zhou L. et al., 2013e)
SN 2013ar	Ia	08:37:45.02	+49:28:32.2	0.052	18.9	Mar. 14.5 2013	CBET 3446 (Zhang T. et al., 2013c)
SN 2013ax	Ia	07:20:03.51	+55:55:48.4	0.040	17.4	Mar. 07.6 2013	CBET 3455 (Zhou L. et al., 2013f)
SN 2013be	Ia	12:36:27.67	+11:45:28.1	0.066	19.6	Apr. 05.7 2013	CBET 3470 (Silverman et al., 2013)
SN 2013bf	Ia	08:58:36.07	+54:19:25.7	0.084	18.8	Mar. 28.5 2013	CBET 3471 (Koff et al., 2013)
SN 2013bv	Ic	08:41:21.28	+52:43:30.3	0.060	18.7	Apr. 09.5 2013	CBET 3499 (Zhang K. et al., 2013a)
SN 2013bx	Ia	12:47:24.22	+32:32:50.0	0.078	19.8	Apr. 09.7 2013	CBET 3501 (Zhou L. et al., 2013g)
SN 2013ca	IIP	11:58:43.25	+19:08:56.2	0.043	18.1	May 01.5 2013	CBET 3508 (Zhang K. et al., 2013b)
SN 2013cb	Ia	11:35:01.74	+16:07:16.8	0.051	18.1	May 01.5 2013	CBET 3509 (Zhang T. et al., 2013d)
SN 2013co	Ic	12:55:50.51	+30:30:41.5	0.050	17.7	May 06.5 2013	CBET 3527 (Zhang T. et al., 2013e)
SN 2013cp	Ia	16:19:52.22	+38:56:07.9	0.075	18.5	May 07.6 2013	CBET 3528 (Zhang K. et al., 2013c)
SN 2013cr	Ia	16:11:46.47	+40:51:22.2	0.027	17.5	May 14.8 2013	CBET 3532 (Zhang T. et al., 2013f)
SN 2013cv	Ia	16:22:43.16	+18:57:35.6	0.035	16.5	May 20.8 2013	CBET 3543 (Zhou L. et al., 2013h)
SN 2013cx	Ia	17:04:16.05	+41:30:37.6	0.033	17.7	May 21.7 2013	CBET 3545 (Wang et al., 2013)
SN 2013dw	IIn	16:13:58.84	+42:41:59.0	0.136	18.8	Jul. 02.6 2013	CBET 3585 (Zhou L. et al., 2013i)
SN 2013ec	Ia	16:27:50.26	+40:28:21.3	0.081	19.0	Jul. 02.6 2013	CBET 3595 (Zhang J. et al., 2013a)
SN 2013eh	Ia	16:16:09.19	+38:32:53.0	0.038	16.6	Jul. 19.5 2013	CBET 3601 (Zhang T. et al., 2013g)
SN 2013fo	Ia	01:20:31.94	+12:03:12.2	0.054	17.7	Sep. 24.6 2013	CBET 3663 (Mo et al., 2013)
SN 2013gf	Ia	09:05:26.46	+56:24:12.4	0.100	18.3	Nov. 06.9 2013	CBET 3702 (Zhang J. et al., 2013b)
SN 2013gm	IIP	11:34:21.16	+15:39:33.1	0.017	17.5	Nov. 20.9 2013	CBET 3726 (Zhang J. et al., 2013c)
SN 2013gs	Ia	09:31:08.87	+46:23:05.4	0.017	17.3	Nov. 29.8 2013	CBET 3734 (Zhang J. et al., 2013d)
SN 2013hp	Ia	23:13:59.72	+24:53:38.9	0.028	18.0	Dec. 12.4 2013	CBET 3764 (Zhang J. et al., 2013e)
PSN J12541585	Ia	12:54:15.85	+09:26:25.9	0.045	17.4	Feb. 18.3 2013	ATEL 4808 (Cao et al., 2013)
PSN J12393328	Ic	12:39:33.28	+15:25:52.0	0.072	19.4	Feb. 22.8 2013	ATEL 4851 (Walton et al., 2013)
PSN J12533306	Ia	12:53:33.06	+27:42:51.7	0.092	19.2	Mar. 03.8 2013	ATEL 4860 (Nicholl et al., 2013)
PSN J09040805	II	09:04:08.05	+47:42:28.0	0.047	18.8	Nov. 17.8 2013	ATEL 5623 (Arcavi et al., 2013)
PSN J12452873	II	12:45:28.73	+29:51:04.0	0.050	18.6	Dec. 22.8 2013	ATEL 5700 (Challis et al., 2013)

term rise with a possible variation on a time scale of days. Analysis of this light variation could help to understand the flux contribution of the accretion disk to the quasar emission at different timescales.

4 SUMMARY

This paper introduces the first-year performance of Tsinghua University-NAOC Transient Survey. The observation system and the data reduction pipeline works overall well during the first year survey, and more than 50 SNe and a lot of other transients (e.g., CVs, novae, Quasars/AGNs and variables) have been detected. For some bright SNe and other interesting transients, the photometric and spectroscopic follow-up observations are triggered immediately after their discoveries. From the statistics of the first-year sample of SNe Ia, we found that 80% of them were discovered before or being close to their maximum light. In particular, it should be pointed that 5 out of 30 SNe Ia were detected at phases around or earlier than two weeks before their maximum light. This number will increase significantly once another two telescopes (one is located at Xinjiang Observatory near Urmqi and the other is at Xuyi Observatory) join our survey network in the next year. Based on current statistics, our survey can provide the supernova community a sample of above 50 extremely young SNe Ia (e.g., $t < -10$

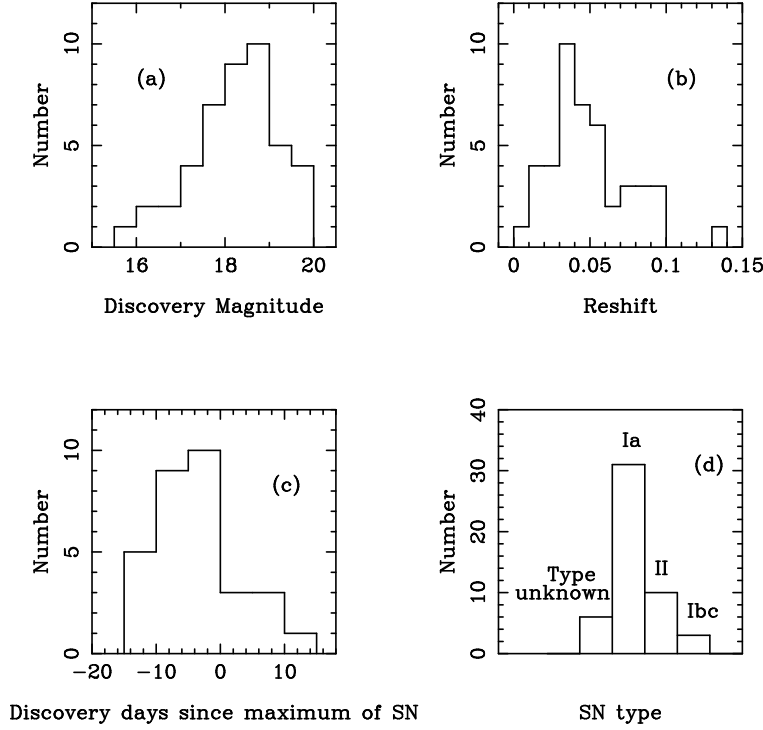


Fig. 4 The statistic properties of the TNTS SNe. Panel (a): histogram of the SNe magnitude at discovery; Panel (b): the redshift distribution of the TNTS SN sample; Panel (c): histogram of SNe Ia age on their discovery. Panel (d): histogram of SNe type.

days) during its four year operations. Such a sample with early observations will definitely increase our knowledge about SN Ia diversities and their physical origins.

Analysis of a small portion of the survey field leads to the discovery of about 150 variables of different types (including 37 new ones), with periods ranging from hours to years. From our current data, we estimate that about 1500-2000 variables can be detected from the entire survey fields of the TNTS, which will be a significant contribution to the study of variable stars.

Acknowledgments: This work has been supported by the Chinese National Natural Science Foundation of China (NSFC grants 11203034). The work of X. Wang is supported by NSFC 11178003, 11325313, Tsinghua University Initiative Scientific Research Program, and the Major State Basic Research Development Program (2013CB834903). This work is partially supported by the Strategic Priority Research Program of the Chinese Academy of Sciences, Grant No. XDB09040300, and by the Main Direction Program of Knowledge Innovation of Chinese Academy of Sciences (No. KJCX2-EW-T06), and by the National Basic Research Program of China (973 Program), No. 2013CB834902, 2014CB845704 and 2014CB845702, and by the Chinese National Natural Science Foundation grants No. 11433005, 11073032, 11373035, 11203031, 11303038 and 11303043.

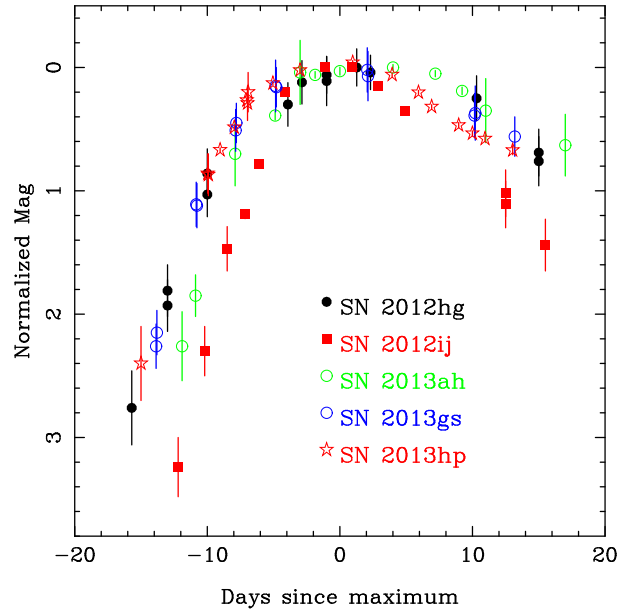


Fig. 5 The R -band (unfiltered) light curves of some young type Ia SNe discovered by the TNTS. All the light curves are normalized to the peak magnitudes and dates for a better comparison.

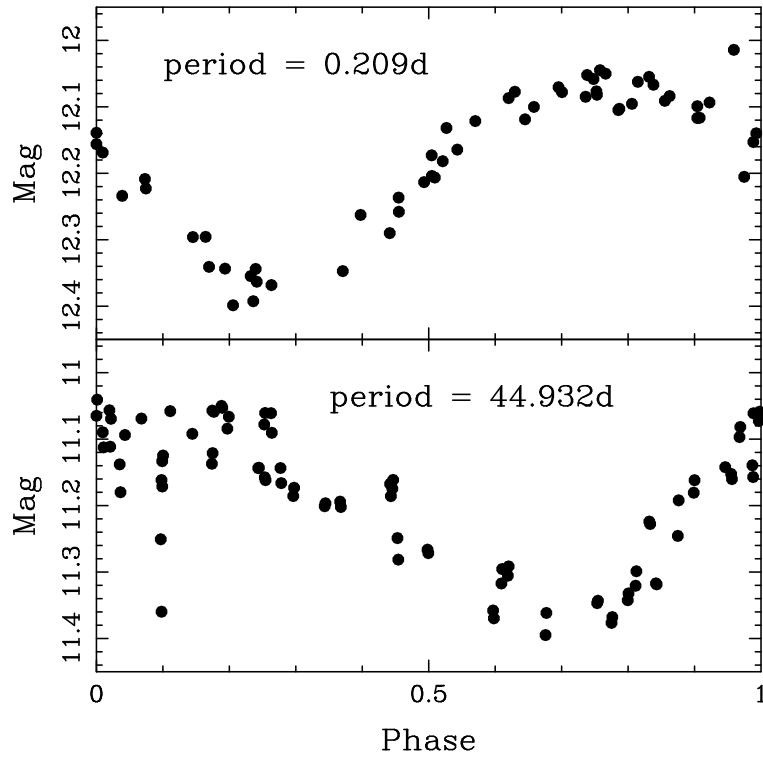


Fig. 6 Example for two periodic variable stars newly discovered during the survey. Top panel: the unfilter phase light curve with a period of 0.209 days; Bottom panel: phase light curves of another variable with a period of 44.932 days.

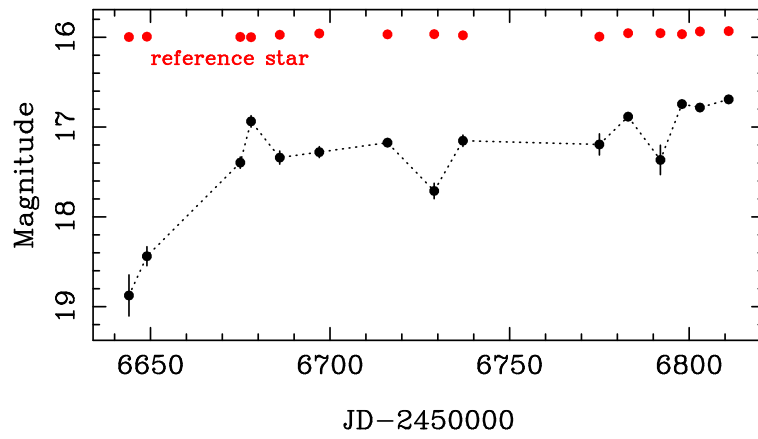


Fig. 7 The unfiltered light curve of a known quasar FSRQ J131059.4+323334 obtained by the TNTS. The red dots are the light curve of reference star.

References

- Arcavi, I., et al. 2013, ATel, 5623, 1
- Baltay, C., et al. 2013, PASP, 125, 683
- Bertin, E. & Arnouts, S. 1996, A&A, 317, 393
- Bertin, E., Mellier, Y., Radovich, M., et al. 2002, in ASP Conf. Ser. 281, *Astronomical Data Analysis Software and Systems XI*, ed. D. A. Bohlender, D. Durand, & T. H. Handley (San Francisco, CA: ASP), 228
- Bertin, E. 2006, in ASP Conf. Ser. 351, *Astronomical Data Analysis Software and Systems XV*, ed. C. Gabriel, C. Arviset, D. Ponz, & E. Solano (San Francisco, CA: ASP), 112
- Blondin, S. & Tonry, J. L. 2007, ApJ666, 1024
- Cao, Y., et al. 2013, ATel, 4808, 1
- Chen, J. et al. 2014 in preperation
- Challis, P., et al. 2013, ATel, 5700, 1
- Cousins, A. W. J. 1981, *South African Astron. Obs. Circ.*, 6, 4
- Drake, A. J., et al. 2009, ApJ, 646, 870
- Elenin, L. & Molotov, I. 2013, CBET, 3430, 1
- Healey, S. E., et al. 2008, ApJS, 175, 97
- Howerton, S. et al. 2012, CBET, 3353, 1
- Huang, F., et al. 2012, *Research in Astron. Astrophys. (RAA)*, 12, 1585
- Inserra, C., et al. 2013, CBET, 3415, 1
- Johnson, H. L., et al. 1966, *Comm. Lunar Planet. Lab.* 4, 99Z, ed. R. Wang (Cambridge: Cambridge Univ. Press), 41
- Kaiser, N., Aussel, H., Burke, B. E., et al. 2002, *Proc. SPIE*, 4836, 154
- Keller, S. C., et al. 2007, *Publications of the Astronomical Society of Australia*, 24, 1
- Koff, R. A., et al. 2013, CBET, 3471, 1
- Law, N. M., Kulkarni, S. R., Dekany, R. G., et al. 2009, PASP, 121, 1395
- Li, W., et al. 2011, MNRAS, 412, 1441
- Luppi, F., et al. 2013, CBET, 3383, 1
- Marion, G. H., et al. 2013, CBET, 3370, 1
- Mo, J., et al. 2013, CBET, 3663, 1
- Nicholl, M., et al. 2013, ATel, 4860, 1
- Silverman, J., et al. 2013, CBET, 3470, 1
- Stetson, P. B. 1996, PASP, 108, 851
- Tomasella, L., et al. 2012a, CBET, 3362, 1
- Tomasella, L., et al. 2012b, CBET, 3366, 1
- Tyson, J. A., Wittman, D. M., Hennawi, J. F., & Spergel, D. N. 2003, *Nucl. Phys. B: Proc. Suppl.*, 124, 21
- Walton, N., et al. 2013, ATel, 4851, 1
- Wang, X., et al. 2008, ApJ, 675, 626
- Wang, X., et al. 2012, CBET, 3344, 1
- Wang, X., et al. 2013, CBET, 3545, 1
- Yao, X., et al. 2014, in preperation
- Zhao, X., et al. 2012, CBET, 3330, 2
- Zhang, J., et al. 2012a, *Astronomical Research Technology*, 9, 411
- Zhang, J., et al. 2012b, CBET, 3336, 1
- Zhang, J., et al. 2013a, CBET, 3595, 1
- Zhang, J., et al. 2013b, CBET, 3702, 1
- Zhang, J., et al. 2013c, CBET, 3726, 1
- Zhang, J., et al. 2013d, CBET, 3764, 1
- Zhang, J., et al. 2013e, CBET, 3734, 1
- Zhang, K., et al. 2013a, CBET, 3499, 1

Zhang, K., et al. 2013b, CBET, 3508, 1
Zhang, K., et al. 2013c, CBET, 3528, 1
Zhang, T., et al. 2012, AJ, 144, 131
Zhang, T., et al. 2013a, CBET, 3395, 1
Zhang, T., et al. 2013b, CBET, 3424, 1
Zhang, T., et al. 2013c, CBET, 3446, 1
Zhang, T., et al. 2013d, CBET, 3509, 1
Zhang, T., et al. 2013e, CBET, 3527, 1
Zhang, T., et al. 2013f, CBET, 3532, 1
Zhang, T., et al. 2013g, CBET, 3601, 1
Zhang, T., et al. 2014, in preperation
Zhou, X., et al. 2003, A&A, 397, 361
Zhou, L., et al. 2012, CBET, 3360, 1
Zhou, L., et al. 2013a, CBET, 3369, 1
Zhou, L., et al. 2013b, CBET, 3394, 1
Zhou, L., et al. 2013c, CBET, 3406, 1
Zhou, L., et al. 2013d, CBET, 3427, 1
Zhou, L., et al. 2013e, CBET, 3443, 1
Zhou, L., et al. 2013f, CBET, 3455, 1
Zhou, L., et al. 2013g, CBET, 3501, 1
Zhou, L., et al. 2013h, CBET, 3545, 1
Zhou, L., et al. 2013i, CBET, 3585, 1